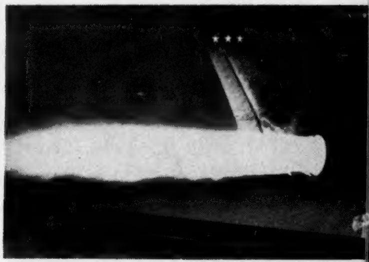
JUNE, 1959

The Research Engineer

Published by the Georgia Tech Engineering Experiment Station



HEAT,
SCREECH,
AND
NUCLEAR POWER

Industrial Isotopes - page 10

The Research Engineer

VOLUME 14, NO. 3 **JUNE, 1959**

Published five times a year by the Engineering Experiment Station
Georgia Institute of Technology, Atlanta, Georgia

the station

the staff

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the cover

Cigarette smoke is one of the most researched subjects of the century, and consequently the nebulous stuff is no stranger to the laboratories of science. But the experimental apparatus in Georgia Tech's Mechanical Engineering Laboratory, where the three cover photographs of cigarette smoke were taken, has nothing to do with the cancerous effects of nicotine, etc. Rather, this ever-present essence of tobacco is used as a convenient means of displaying certain phenomena of sound waves during research in acoustics. A description of this current research, including an explanation of how the cover photographs were made, begins on page 4 of this issue. The other two photographs in the cover montage, those of the rocket and jet flames, are taken from other illustrations in this issue.

THE RESEARCH ENGINEER is published five times a year in February, April, June, October and December by the Engineering Experiment Station, Georgia Institute of Technology. Second-class postage paid at Atlanta, Georgia.

GEORGIA TECH'S rapid expansion in research and development in the field of radioisotopes is most gratifying. Over $250,000 in contracted research work is already scheduled to be performed in the recently-completed Radioisotopes and Bioengineering Laboratory.

The largest contract included in this work is one from the Atomic Energy Commission establishing a special research and development program at Tech aimed at fostering the use of radioisotopes among industries in the South.

Tech's research staff is already working on this program. For, without such research help, most southern firms would be forced to wait for the gradual development of radioisotope applications and techniques—a wait that could be costly. With the new program at Tech (and a similar one for different industrial areas at the Triangle Research Institute in North Carolina), fast, custom- designed progress can be made for the industries that are most important in our southern industrial economy.

This type of research program also is extremely valuable to the educational programs at Tech. The faculty members and graduate students who will do much of the work will broaden greatly their knowledge and professional capabilities in this relatively new field.

As we have said before, Georgia Tech's objectives in service to industry are not merely to answer the pressing operational problems of today. Our advanced work in radioisotope development is another example of our continuing efforts to anticipate the future, and to lead industry to early applications of the technologies of tomorrow.

E. D. Harrison

President

U.S. Navy

The great heat of jet engines is shown in this view of an F7U-3 Cutlass with after-burner on. Combination of heat and certain acoustic vibrations may cause engine failure.

SOUND, FLUID FLOW AND HEAT TRANSFER

The little-understood but important effects of resonance on heat transfer are studied with special acoustical apparatus

by Thomas W. Jackson,
Research Professor, Mechanical Engineering

and Jack M. Spurlock,
Instructor, Chemical Engineering

THE JET ENGINE opened up the supersonic flight age. With its high-temperature and high-velocity gases it gave engineers the means to push aircraft at speeds in excess of the velocity of sound. Soon the rocket will take man into space. The jet engine and rocket, therefore, have furnished the means of obtaining flight speeds which would have seemed impossible to a man of the 19th century. These new engines, however, are not perfect. They are plagued with vibrations that cause the high temperature gases to overheat their structures. Basic knowledge of the effects of resonance on heat transfer is lacking.

One of the experimental devices used for almost a century in studies of the velocity of sound in air and in other gases is the well known Kundt tube. In 1866 Kundt showed that if stationary longitudinal waves are set up in the air in a long tube containing dust, the wavelength of the sound is indicated by little collections of dust which form at the nodes. The velocity of sound then is the product of the wavelength times the frequency of the vibration. The acoustical phenomena observed by Kundt and others led Lord Rayleigh in 1883 (Reference 1) to analyze theoretically the circulation of the air between the nodes of a standing wave. He found that circulation takes place as shown in Figure 1. Lord Rayleigh's theoretical work gave, therefore, an explanation of the ridges of dust which formed at the nodes in a Kundt tube.

E. N. da C. Andrade, Professor of Physics at the University of London, in 1931 presented a paper "On the Circulation Caused by the Vibration of Air in a Tube" (Reference 2) in which he showed pictures of the motion of air under the influence of resonant acoustic forces. To indicate the air flow, Andrade used cigarette smoke, which he illuminated in various planes of the tube. He verified

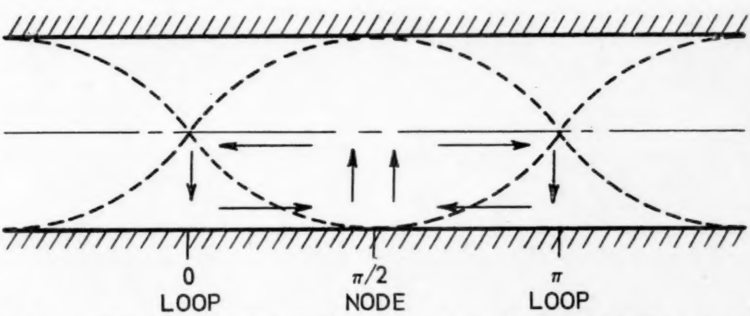


FIGURE 1. THEORETICAL PREDICTION OF FLOW BY LORD RAYLEIGH

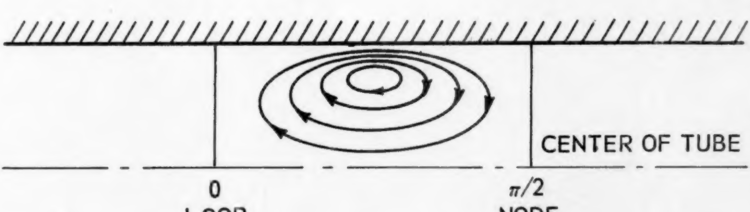


FIGURE 2. ANDRADE'S EXPERIMENTAL 1/4 WAVELENGTH FLOW PATTERN

the theoretical prediction of Lord Rayleigh. A typical flow cell obtained by Andrade is shown in Figure 2.

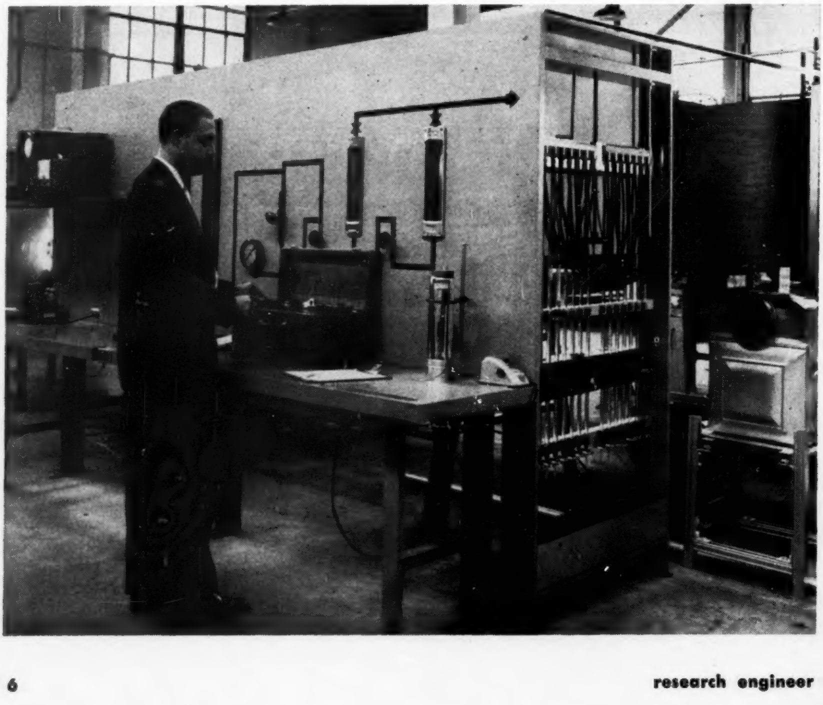
The work on fluid flow effects due to resonant vibrations continued through the years; however, it was not until jet engines and rockets ran into the trouble of "skreech" that a serious attempt was initiated to understand the effects of sound on heat transfer. Skreech is the name given to the noise a rocket or jet engine emits when it goes into resonance. It is accompanied by a great increase in the heat transfer rate from the hot combustion gases to the engine walls. This causes, in many cases, premature failure of the structure of the engine.

In 1955 a project was undertaken by the Engineering Experiment Station concerning the effects of resonant vibration on heat transfer in a vertical tube. This work, which was sponsored by the National Advisory Committee for Aeronautics (NACA) resulted in data that indicated the heat transfer rate could be increased over 100 per cent at certain sound intensity levels. The original NACA work resulted in two publications (References 3 and 4).

Currently two projects on heat transfer, fluid flow, and acoustic vibrations are underway at Georgia Tech. Wright Air Development Center (WADC) is sponsoring a project designed primarily to answer these questions:

1. How does resonance affect heat transfer rates?
2. What is the order of magnitude of the resonant heat transfer effect?
3. What are the parameters influencing the heat transfer coefficient in resonant systems?

Figure 3. Co-author Spurlock with equipment to study resonance and heat transfer. Tubes at right collect condensed steam, from which transfer rates are calculated.
Bill Diehl, Jr.



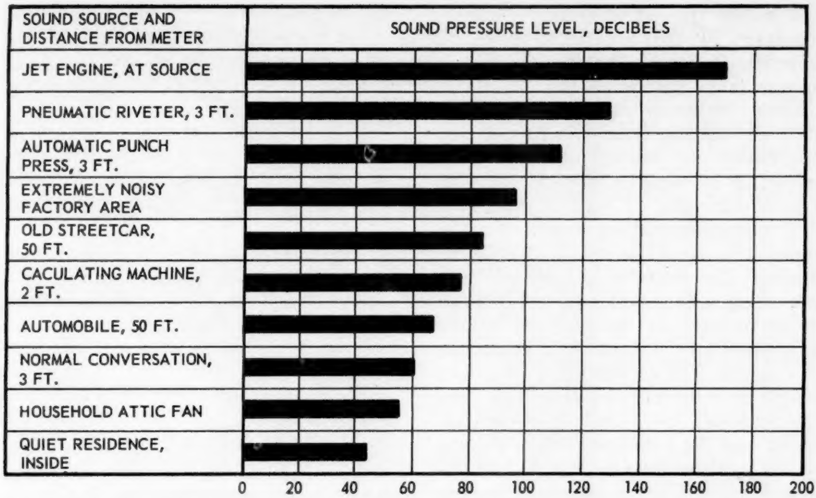


FIGURE 4. JET ENGINE IS ONE OF LOUDEST OF MAN'S MACHINES

The experimental apparatus utilized in the WADC study is shown in Figure 3. A 3.75-inch I.D. by ten-foot long heated tube, which is resonated by means of a loudspeaker at one end, is instrumented for the measurement of temperatures and heat flow rates along its length. By measuring the flow of air through the tube, determining its temperature rise, and knowing the temperature and heat flow rate through the tube wall, the heat transfer coefficient can be determined. When the basic parameters influencing the heat transfer coefficient in resonant systems are determined, it is anticipated that this knowledge can be applied to making more compact heat exchangers and eliminating troubles in jet engines. This may reduce the cost and size of heat transfer devices and, because heat utilization is one of our most important industrial problems, may effect significant economies to a number of industrial processes.

Current preliminary data indicate that below approximately 145 decibels of sound pressure there is no appreciable acoustic effect on the rate of heat transfer. Decibels are a relative measure of sound intensity; using accepted methods of measurement, one would find that at 75 feet from the tailpipe of a jet engine the sound pressure level or intensity is approximately 145 decibels. Normal conversation at three feet is about 60 decibels; however, because decibels are logarithmic in nature they cannot be added directly. In other words, one conversation at 60 decibels added to another at 60 decibels gives a new intensity of about 63 and not 120 decibels as one might expect. Normally a doubling of the sound intensity results in a 3 decibel increase in the sound pressure level. Figure 4 indicates the magnitudes of various types of sounds.

In view of the fact that the work at Georgia Tech indicates very little heat transfer effect below 145 decibels and because only in comparatively recent times have sound levels of the necessary intensity been generated in jets and rockets, it is not surprising that little thought has been given to the effects acoustic vibrations have on heat transfer rates.

The other project at Georgia Tech is sponsored by the Air Force Office of Scientific Research. The purpose of this project is to determine the effects of acoustic frequency and sound pressure level on the formation of and velocity distribution in convection cells which are set up by resonant acoustic forces in a horizontal tube.

The experimental equipment for the above project is shown in Figure 5. Basically it consists of an insulated box containing a four-foot long pyrex tube, 90 millimeters in diameter. This tube is resonated by a loud-speaker coupled to one end. The air flow cells are made visible, in a manner similar to that used by Andrade, by introducing cigarette smoke into the tube and illuminating the smoke particles by a curtain of high intensity light. Photographs (a) through (e) of Figure 6 show typical flow patterns which have been obtained for various frequencies. These photographs, while interesting, are still too crude to be of scientific value. Much work is yet to be accomplished before a complete understanding of the effects of sound pressure on fluid flow is available.

The research projects described above are being performed in the Research Building of the School of Mechanical Engineering.

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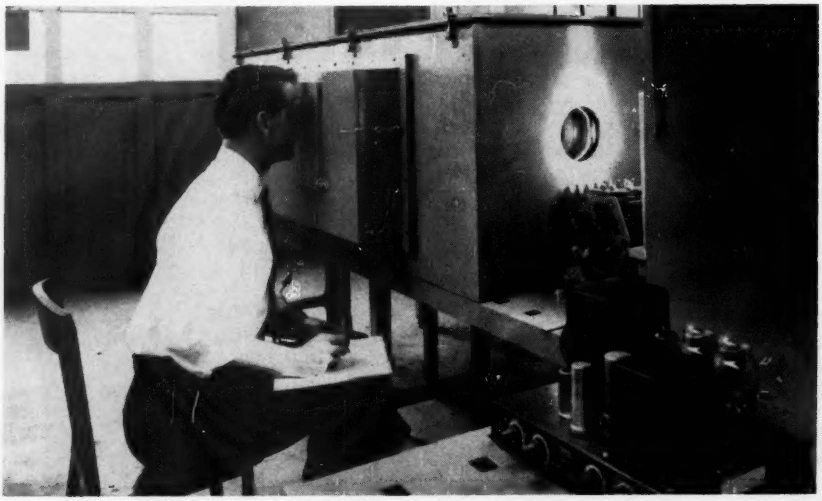
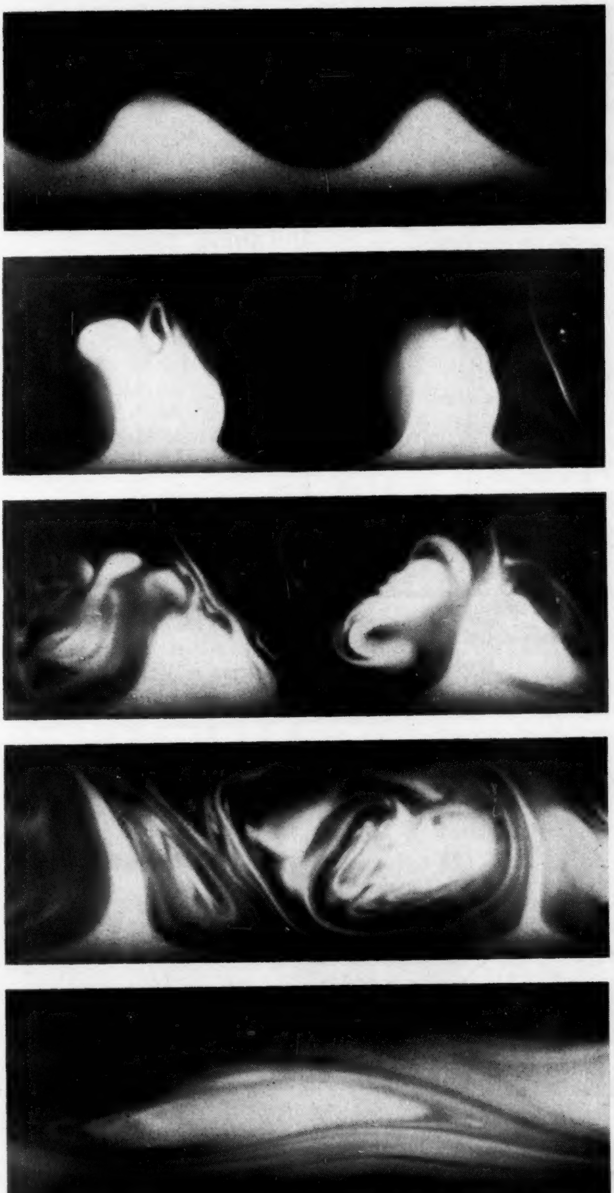
Figure 5. Engineer Harold Johnson views smoke vortices (see opposite page) which are illuminated in pyrex tube. Andrade developed the experimental method in 1931.





(a)
2000 cycles per second

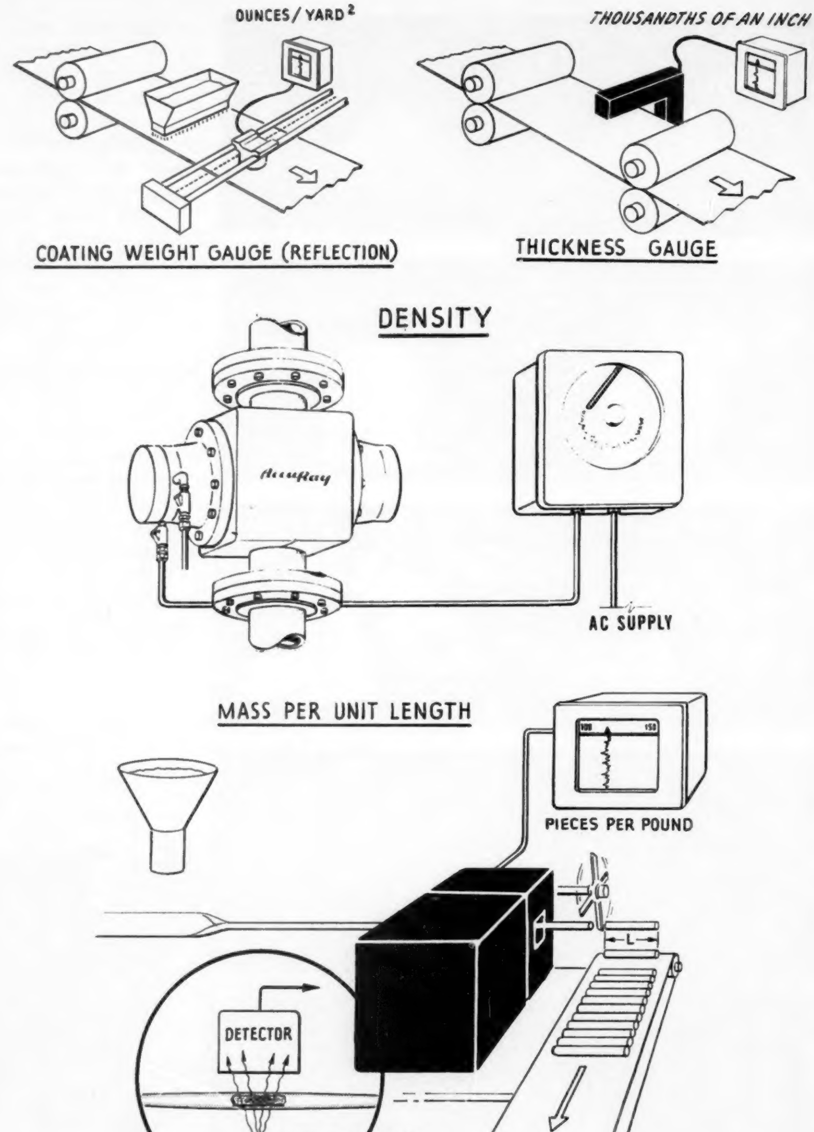
(b)
1800 cycles per second

(c)
1680 cycles per second

(d)
1250 cycles per second

(e)
875 cycles per second

FIGURE 6. PHOTOS OF VORTEX FORMATIONS AT VARIOUS FREQUENCIES



Drawings Courtesy Industrial Nucleonics Corporation

SOME OF THE MANY PRESENT USES OF RADIOISOTOPES IN INDUSTRY

THE INTREPID ISOTOPES

A Report on the Symposium on the Industrial Uses of Radioisotopes

RADIOISOTOPES are used by industry "for everything from soup to nuts," the director of the Atomic Energy C mmission's Office of Isotopes Development, Dr. Paul C. Aebersold, said at Georgia Tech last month. Dr. Aebersold outlined the uses of radioisotopes in his keynote address to the Symposium on the Industrial Uses of Radioisotopes held at Tech on May 11 and 12.

Dr. Aebersold explained that the consumer of many types of canned goods, including soup, is kept from being shortchanged today because the level of the contents has been measured by a sensitive radioisotope level gauge during the filling operation. If the can is improperly filled, the error is corrected. Almost everything manufactured in sheet form —paper, plastic metals, adhesive tape, rubber, and sandpaper, for example—is improved by isotope gauges, he added. Isotopes are also used to study the wear of equipment parts, the efficiency of washing machines, and in a great variety of other industrial processes.

Wide Range of Topics

Dr. Aebersold was followed by 31 outstanding speakers in various fields of radiation technology. The symposium was attended by 175 representatives of industrial firms from 21 states and two foreign countries, plus a number of college and high school students.

During the symposium 24 scientific and engineering papers were presented by experienced men in the fields of radioistopes study and application. The wide range of subject matter included the following topics:

Economics of Radioisotopes in Industry

Radioisotopes Gauging Techniques

Radioisotopes as Industrial Tracers

Training, Information and Education for Industrial Isotopes Utilization

Health, Safety and Regulatory Controls

Luminescence

Evaluation of High Speed Tool Wear

Uses of Cobalt-58 and -60 Labelled Vitamin B12

Applications of Radioisotopes in High Temperature Ceramic Processes

Radiochemicals and Some Applications

Other papers described the uses of radioisotopes in paper mills, textiles, preservation of foods, petroleum and general manufacturing.

The conference participants were conducted on a tour of Georgia Tech's Radioisotopes and Bioengineering Laboratory (*Research Engineer*, February, 1959), the first completed unit in the Institute's rapidly expanding nuclear science and engineering program.

AEC Contract for Tech

The symposium was sponsored by the Lockheed Nuclear Products Division of Lockheed Aircraft Corporation, and Georgia Tech, in cooperation with the AEC's Office of Isotopes Development. Recently Georgia Tech received a $140,000 contract grant from the Office of Isotopes Development to establish a radioisotopes research and development program.

The grant was the fourth of its type

issued by the AEC under an extensive program to promote the use and production of radioisotopes among industries in this country. Other research organizations who have received similar grants include Massachusetts Institute of Technology, The University of Chicago, and the Triangle Research Institute in North Carolina. Tech will work cooperatively with Triangle Research Institute to serve the South through this program.

The program—to be administered by Tech's Engineering Experiment Station through the Radioisotopes and Bioengineering Laboratory—will be divided into five areas of endeavor: (1) feasibility studies of radioisotopes techniques and applications of possible utility in industry, (2) laboratory investigations and development of techniques for radioisotopes applications, (3) evaluation of the information obtained from the research and development program in relation to practical applications, (4) field demonstration of any resultant techniques for applications which appear promising, and (5) dissemination of significant developments or results to industry in cooperation with the Office of Isotopes Development.

Emphasis in the Tech program will be placed on industrial technical problems important to the southeastern area of the U. S. Some of the specific areas to be investigated by Tech are: (1) deagglomeration (breaking up the clay particles into more usable size) of kaolin by high-energy, ionizing radiation, (2) use of radioisotopes in the study of modifications of platinum catalysts, (3) studies of the reactions involved in etching of copper photoengraving plates, and (4) application of radioisotope techniques to road building problems. Specific research problems will be developed and submitted by Georgia Tech for evaluation by the AEC from time to time under the project.

The symposium on the industrial uses of radioisotopes was a part of the development program to acquaint industry in this area with the potential value and the broad scope of radioisotope applications.

At a break in the conference, Dr. Fred Sicilio (right), head of Tech's new Radioisotopes and Bioengineering Laboratory, talks with several visiting industrialists.

Atomic Energy—
PROMISE FOR THE FUTURE

*By Jerome D. Luntz, Editor of Nucleonics Magazine, Guest Speaker at Radioisotopes Symposium**

THE OTHER DAY I was rereading parts of the transcript of the first public congressional hearings ever held on atomic energy. These were conducted in 1945 by a special Senate committee under the late Brien McMahon. In his opening remarks, Senator McMahon said, "The release of atomic energy is certain to affect every phase of our life. Like the discovery of steam and of electricity, this may well hold the promise of tremendous benefits to mankind."

This prediction of things to come was rather modest compared with those of many who let their imaginations run wild. Nevertheless, the mood of the times was reflected in our first atomic energy law, the McMahon Act, wherein it was implicitly stated that "industrial, commercial or other nonmilitary use of fissionable material or atomic energy" might well have profound "social, political, economic and/or international effects."

In actuality, perhaps in part because of the almost total preoccupation in the early years with building an atomic weapons arsenal, there have thus far been no profound dislocating effects on society.

Rather than having a revolutionary effect, atomic energy is having an evolutionary one. It is my conviction that this will continue to be the case in the coming decades.

Now, evolution rather than revolution doesn't by any means suggest a lesser impact of atomic energy. For example, the wide variety of applications of radioisotopes being described at this meeting is quite impressive and is very much the "success story of atomic energy," as the AEC's Paul Aebersold has termed it. Radioisotopes are having an *evolutionary* effect. They have quietly become extremely useful in so many aspects of medicine and industry.

Although there has been so very much noise about nuclear power and its impact on the world, nuclear power will actually become important in an evolutionary way too—quietly. Nuclear power will not suddenly turn the deserts of the world green, but as it becomes economically competitive in various parts of the world it will find application in those places.

Having painted what I believe is a sober picture of the realities of atomic energy, I would now like to jump off the deep end and tell you what I feel the impact of atomic energy will be ten years from now, in 1969. I shall do this because it will provide a good basis for understanding the problems and programs of today.

I predict the following 13 things will be true in 1969 (not in any particular order):

1. Central-station nuclear power will be economically competitive in the United States and in Europe.

**This article is the text of Mr. Luntz's banquet address at the Radioisotopes Symposium (see page 11). The views expressed are not necessarily those of Georgia Tech personnel.—Ed.*

2. The bulk of the power plant capacity planned for 1969 and thereafter will be nuclear.

3. The U. S. will have at least 2,000,000 kw(e) out of a total of about 15,000,000 kw(e) in the world.

4. The entire Navy will be nuclear propelled, as will all new Navy ships.

5. Nuclear power will be economic for merchant ships.

6. The U. S. Air Force will have nuclear planes in the air.

7. The Army will have transportable power reactors—transportable by air, or via barge or trailers.

8. Rockets and possibly space vehicles will be propelled by nuclear energy.

9. Process heat from a power reactor will be economic.

10. Nuclear explosives will be in use for peaceful purposes.

11. The technical feasibility of controlled thermonuclear reactors will be proven.

12. It will be possible to produce sizable amounts of power from direct-conversion nuclear devices.

13. Radiation from radioisotopes and accelerators will be commonplace for industrial process and product control.

This may sound like a dreamy, unrealistic set of predictions to some of you. I do not feel that way. I believe all these things will happen in 1969. I am what I'd call a "realistic optimist." But let me assure you that none of these things will happen by themselves. Imagination, hard work and money will be necessary to bring them about.

And this, of course, points up the big dilemma of today in the U. S. and, I suppose, elsewhere in the world (maybe even in the Soviet Union). The conflict stems from the fact we are now living in an age when science and technology are of transcendental importance to our way of living, in fact to our very existence. To serve our own internal needs and to keep pace with foreign competitors, we must maintain a *vigorous* pace in science and technology. The problem is that there are *many* areas that need to be worked on, and there is only a finite number of people and dollars for this work.

A decision to support any particular technology must, of course, be based on an evaluation of its contribution to the national well being. Apart from the economic motivation for supporting a strong peaceful atomic effort, we must recognize and accept the fact that we *have been* and *are* striving to establish the atom as a symbol of peace throughout the world. A key to our success in this effort must be a backing up of our

JEROME D. LUNTZ obtained his Bachelor of Electrical Engineering degree from City College of New York. After several years of engineering and research, including experience at Oak Ridge during the war, Mr. Luntz joined McGraw-Hill Publishing Company in 1947 to help prepare the first issue of *Nucleonics*. He became Chief Editor of that magazine in 1953 and Associate Publisher in 1958. He is a founder of the American Nuclear Society, a member of the New York State Advisory Committee on Atomic Energy, and holds other national positions in the field of nuclear science and journalism.

words with deeds, with solid accomplishments.

Up until this very year, there has been a basic split in Washington on the matter of how important atomic energy is and how fast our work on it must be pushed. There have been those in Congress who have pressed for an unwarranted and too costly crash effort. And there have been those in the Administration who have wanted to hold to the status quo. Not surprisingly, the most reasonable position falls somewhere in between. Fortunately, the thinking in Washington now seems to be along the latter lines.

Now what is it that needs to be done to assure the achievement of the 13 predictions I listed earlier?

Although it is addressed to the civilian power problem, one thing has been done that is basic to all other parts of the field, namely a list of objectives for the U. S. has been agreed upon in Washington. It calls for establishment of unquestioned U. S. leadership in civilian reactor technology including the achievement of competitive power abroad within 5 years and at home within 10 years. To do this will require a research and development program and a plant-building effort that is bound to give a real push to the whole sweep of work in nuclear technology.

The bulk of the R & D work in the coming years will undoubtedly be supported by the Federal government, either through contracts with private organizations or through the AEC's national laboratories. The latter, by the way, have played a key role in the U. S. atomic effort up to this point and will continue to do so, if they are allowed to. I said "are allowed to" because the future role of these labs will be examined by the Joint Committee in hearings shortly.

Having mentioned the matter of the Federal government supporting R & D, I would like to say a word here on the general continuing role of government versus that of private industry, universities, etc. I'm sure you all recall the effect of the original McMahon Act on private activity. One of the framers of the law said, "The field of atomic energy is made an island of socialism in the midst of a free enterprise economy." Of course, this referred primarily to the use and possession of fissionable material. Radioisotopes, on the other hand, have been in wide public use and ownership ever since 1946, through the pioneering efforts of such people as Paul Aebersold.

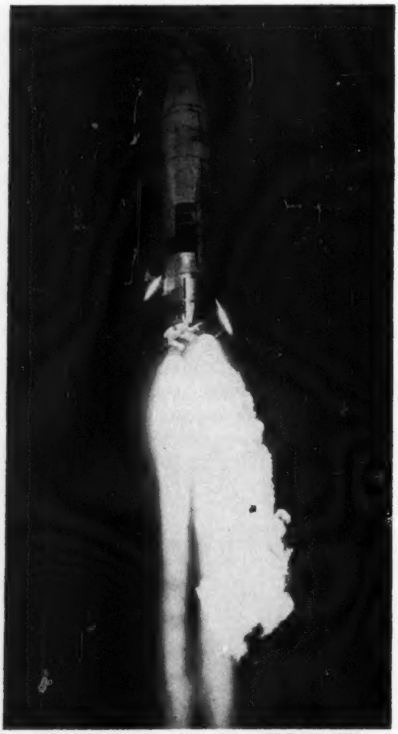
The 1954 revision of the law changed the situation radically and might well be called Year One of private activity in atomic power work.

To my way of thinking, government—Federal, state and local—is going to have a vital and influential role in at least the next ten-year period that I've been discussing. This role will be as promoter, financer and regulator of peaceful activities, and of course as a big R & D facility and a weapons manufacturer. The regulatory task will undoubtedly be a function of government for as long as fissionable and radioactive materials are in use. Two of the other activities—that of promoter and financer—will be on the wane towards the end of this next decade. But during these next five years, the rate of progress in nuclear technology will be materially influenced by the extent of AEC financial support of industrial activity. In the nuclear power field, AEC has been supporting R & D for some years but, this year, in a very controversial plan, AEC is proposing for the first time to offer industry capital subsidies. I feel that capital subsidies have been long overdue to make the government-industry effort the true partnership that it should be.

Having mentioned the important role of government as a promoter of nuclear activity, I must also say that I feel very strongly that this doesn't mean that industry should sit on its hands. Not by any means. In fact, in a field such as radiation technology, it is imperative that every company in it and the industry as a whole do as hard a selling job as possible.

Now I would like to go back to my first prediction which was that nuclear power would be economically competitive in the U. S. and Europe by 1969. I actually think this might be a bit conservative. One major plan that has been proposed foresees competitive power by 1965.

The U. S. nuclear power effort, with the expected addition of about nine projects in this session of Congress, is rolling along pretty well now. We've had a civilian reactor program going for about 10 years. Up until recent months, we were spreading our effort pretty wide by working on a multiplicity of reactor types in a sort of horse race, hoping that at some point it would become evident which was the best horse. Although there may never be a single *best* horse, it is now becoming a lot clearer where our bets should be placed.



U.S. Air Force

Spectacular rocket blast-offs like this ATLAS test may be obsolescent in 1969. To achieve thrust, nuclear-powered rockets may spew only tons of plain water vapor.

The most promising reactor types for the short range—the ones that will bring us economic power within ten years—are the water reactors (pressurized and boiling) and the organic type. We've had the most experience with water reactors as a result of the nuclear Navy program, which has concentrated pretty much on water technology. One large and two small civilian water power recators have been in operation for some time. Three large central-station water reactors are under construction, with one to be in operation early next year.

A big boost to U. S. technology will come through the joint program with Euratom that calls for the building of 1,000,000 kw of nuclear power plant capacity by 1963-65. Although recent surpluses of coal in western Europe have taken the edge off the urgency of the European need for nuclear power, the fact remains that the growth in power requirements and the expected short-term depletion of conventional fuel reserves in Europe are leading to a very aggressive effort there. Proposals for the building of the million kw are due this fall. The plants that will be built will add to the experience of the U. S. and enhance the prospect of getting economic power early. And as we get close to achieving economic power, we will then see the start of a trend away from building conventionally fueled plants.

The easiest prediction for me to make was the one about the nuclear Navy. Highlighted by the exploits of the Nautilus and the Skate, the story of the nuclear Navy has been a dramatic one. The need was there and it is being filled. We will have an all-nuclear Navy by 1969. This means that of the order of 75-100 nuclear power plants will be built for the Navy.

A more difficult prediction to make

was that we'll have nuclear planes (plural) flying by 1969. Here I'm going more on faith and knowledge of the need than on accomplishments up to this point. This part of the nuclear program is a black one indeed. It has been beset with troubles right from its start about 10 years or so ago. First, of course, is the very difficult technical problem that has been presented to the designers of a nuclear plane, the need to get a high-performance power plant into a relatively light package. Superimposed on the technical problems have been political-administrative ones — primarily indecision an ddisagreement within the Administration. The Washington attitude has been totally unfair to those working on the program. Full and consistent support has not been forthcoming. Committee after committee has examined the project, each with seemingly different reactions. This is an important project. The Administration should give it the firm push that is needed to get a plane into the air, and should give it that push this very year. This is what would be necessary for my prediction to be realized.

The Army program, although much smaller in size than the others, and although it got started quite late, is doing very well. The objective is to develop a family of small reactors capable of meeting a variety of military requirements—stationary, mobile and propulsion—in the range of several hundred kw to 40,000 kw. Two small experimental reactors, one at Fort Belvoir and one in Idaho, are in operation.

The military advantage of nuclear power for the Army is clear. For many remote military bases, especially for arctic installations, the fossil fuel supply accounts for a large part (as much as 70-80 percent) of the logistic effort. Each electrical megawatt of installed nuclear power plant capacity means an annual logistic saving of up to 20,000 barrels of oil. In terms of shipping, a 20,000 kw(e) nuclear plant would each year save the equivalent of some 700 railroad coal cars or 8-12 oil tankers. In addition, dependence on vulnerable supply lines would be eliminated.

Thus, I feel that I can say that the Army program is going along pretty well and is seemingly getting the support it needs.

The maritime program, on the other hand, may well lag unless it gets a big push. This is another one of the controversies in Washington. Congress is *for* a big effort here; the economy-minded Administration is *opposed* to it. The N. S. Savannah, which will be launched this summer, is the cornerstone of the program. But it is *only* nuclear merchant ship being built by the U. S. It is quite conceivable that other countries will move ahead of us on this and gain a commanding lead on our merchant fleet unless adequate support is forthcoming.

The only other area that I want to comment on is fusion, controlled thermonuclear power. Perhaps the most important accomplishment of the 1958 Geneva atoms-for-peace conference was that the world got a true assessment of where fusion work stood—that fusion was not going to replace fission even before fission was economic. What came out of Geneva was a realization that a long road lies ahead to the accomplishment of four important stages: (1) a self-sustaining reaction, (2) a reaction that produces at least as much power as the device consumes, (3) a device that is a net power producer, and (4) an economic fusion device. We have an ambitious fusion program in the U. S. It is probably the largest in the world. Through it, we should achieve at least the first stage in the next 10 years.

As you can see, great strides are being made in many areas of nuclear technology. But to reach the goals that I have staked out for the next 10 years, we need an imaginative joint effort between government and private industry. We need to be discriminating—and this applies to all areas of science and technology—and to recognize the programs that need to be supported strongly and to give those our utmost. And, at the same time, we need to be realistic optimists.

publications

McDaniel, E. W. and H. R. Crane, "Measurements of the Mobilities of the Negative Ions in Oxygen and in Mixtures of Oxygen with the Noble Gases, Hydrogen, Nitrogen, and Carbon Dioxide." Reprinted from The Review of Scientific Instruments, September, 1957. Reprint 122. Gratis.

The mobility constants for oxygen negative ions in He, Ne, A, Kr, Xe, H_2, N_2, and CO_2, each containing various partial pressures of O_2 were measured, and extrapolations to zero partial pressure of O_2 were obtained. A measurement of the mobility of the negative ion in 100% oxygen was also made. The value found for the latter was 2.46 ± 0.05 cm^2/v-sec at STP. It was shown that the mobility values referred to a single species of oxygen ion, but the question as to whether it was O_2- or O_3- was not resolved. A time-of-flight method was used, in which the ions were made by the passage of alpha particles through the gas, and detected by a proportional counter.

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Meeks, M. L. and J. C. James, "On the Influence of Meteor-Radiant Distributions in Meteor-Scatter Communication." Reprinted from the Proceedings of the IRE, December, 1957. Reprint 126. Gratis.

The relative effectiveness of various regions of the atmosphere in furnishing usable meteor trails is examined on the basis of several distributions of meteor radiants. An idealized distribution in which the radiants lie near the ecliptic is analyzed and the results compared with previous calculations for a uniform radiant distribution. Experimental data on a 250-km link between Knoxville, Tenn., and Atlanta, Ga., show evidence of a rather diffuse concentration of radiants near the ecliptic. A method for predicting the contributions of meteor showers to forward-scatter propagation is developed. As an example the August Perseid shower is studied on the Knoxville-Atlanta link. Experimental data show good agreement with the shower analysis.

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Orr, Clyde and Roy A. Martin, "Thermal Precipitator for Continuous Aerosol Sampling." Reprinted from The Review of Scientific Instruments, February, 1958. Reprint 128. Gratis.

Thermal precipitation is attractive for airborne particle collection because of the high collection efficiencies which may be attained and the convenient examination of the deposit. Most thermal precipitators, however, have very low sampling capacities or flow rates. To take fullest advantage of the desirable features of thermal precipitation, a new precipitator was designed and constructed. It operated continuously, and deposited particles upon a moving tape or substrate. Complete collection of particles resolvable with an electron microscope was attained in a 3-in. diameter precipitating zone at a flow of 1 l/min.

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Grune, W. N., and T. H. Lotze, "Redox Potentials in Sludge Digestion." Reprinted from Water and Sewage Works, January 1958. Reprint 130. Gratis.

This article presents the results of research on two laboratory sludge digesters, equipped with redox potential cells. One digester contained radioactive phosphorus; the other was a control. The authors conclude "that an excellent correlation between ORP and digestion progress can be obtained," and they believe "that ORP and pH measurements will offer a convenient and valuable means to improve the economical operation of sludge digesters." A novel type of non-plugging and non-polarizing flow cell for measurement of redox potential is described.

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McDaniel, E. W., and T. A. Elliott, "Design and Uses of a Light-Water-Moderated Subcritical Assembly." Reprinted from American Journal of Physics, March, 1958. Reprint 132. Gratis.

The utility of subcritical assemblies in the development of nuclear reactors and as educational tools is discussed, and a detailed description of the light-water-moderated, natural uranium assembly at Georgia Tech is presented.

Walton, J. D., Jr. and N. E. Poulos, "Cermets from Thermite Reactions." Reprinted from the Journal of The American Ceramic Society, January, 1959. Reprint 136. Gratis.

The process whereby the components of a thermite are pressed into a desired shape and ignited to form a cermet is described. In this process, the oxide of the cermet (Al_2O_3) is produced from the oxidation of powdered aluminum and the metallic phase is produced from the resulting reduction of its oxide. A third component (clay, Al_2O_3, or MgO) is added to act as a control agent. Methods of compacting and firing are described. A table of oxides reduced by aluminum using this process is presented. The formation of metallic silicides and borides as the metallic phase of a cermet from the appropriate silicates and borates, or metallic oxides with silica or boric acid, is discussed. As an example, $ZrSi_2$ is produced by the reduction of either $ZrSiO_4$ or ZrO_2 and SiO_2, and TiB_2 by the reduction of TiO_2 or B_2O_3. The following advantages may be obtained by this method: (1) inexpensive compositions, (2) low ignition temperatures (1800°F.), (3) high reaction temperatures (5000°F.), (4) short firing time (1 hour), and (5) controlled atmosphere unnecessary. A technique was developed whereby cermet test specimens could be prepared from the thermite reaction between aluminum and zirconium silicate. The tensile strength of the finished cermet is given at room temperature and at 2200°F. The apparatus used for determining these tensile strengths is described. Modulus of rupture data also are given. Other oxide thermites were added to the basic zirconium silicate thermite mixture. The effect of these thermite additions on the strength of the basic thermite is described.

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Georgia Tech Library Staff Association, the Price Gilbert Library, "Theses and Dissertations Accepted in Partial Fulfillment of the Requirements for Graduate Degrees by the Georgia Institute of Technology, 1925-1957." Supplement for 1958 also available. Bulletin 22. Gratis.

Information is listed by the degree-granting school and inludes an alphabetical index of authors. Titles only are given. Abstracts may be obtained through the Graduate Division, Georgia Institute of Technology.

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Mitchell, Lane, and N. E. Poulos, "The Relationship of Structure of Georgia Kaolin to its Viscosity." 1959. Bulletin 23. Gratis.

The direct causes of the variance in viscosity of kaolin suspensions probably cannot be attributed to any one specific factor. Particle shape, size, concentration of suspension, the suspending medium, and added electrolytes affect the viscosity of a kaolin suspension. Kaolins which were laid down at the same geological time may vary considerably in viscosity even though the factors mentioned above are rather similar.

Organic matter, either in the form of humic acid or microorganisms, affects the viscosities of the investigated kaolins. Hydrogen peroxide was used to oxidize the organic matter, and both raw and hydrogen peroxide treated kaolins were tested to ascertain the effect that organic matter had on the viscosity.

Extraneous atttached ions were found to affect the viscosities of the kaolins.

X-ray analysis indicated that hydrogen peroxide and electrodialysis treatments tended to alter the random displacements of the lattice layers of the kaolins; however, the random displacement of the crystal lattice layers did not seem to affect the viscosities of the kaolins.

Electron micrographs revealed that the mineral kaolinite was predominant in the kaolins; however, halloysite was found to be present in the kaolins from Washington County, Georgia. The mineral dickite also appeared to be present in these kaolins.

These and other technical publications may be obtained, and the complete publications list requested, by writing Publications Services, Engineering Experiment Station, Georgia Institute of Technology, Atlanta 13, Georgia.

Edited In Retrospect

• Two days after the radioisotopes symposium was held here (see pages 10-12, this issue), some 900 members of the American Institute of Industrial Engineers arrived at Atlanta's Biltmore Hotel for their tenth annual conference. Georgia Tech was well represented in the list of attendees, committee chairmen, and speakers. Notable for its contribution to advanced thinking in modern industrial engineering was a paper by Dr. Ernst Swanson, senior research economist in the Industrial Development Branch of the Engineering Experiment Station. The paper concerns the economics of product diversification and a quantitative method of evaluating the alternatives.

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Dr. Swanson's paper falls into the realm of operations research, a subject generally enveloping a number of quantitative tools and their use in aiding management decision-making. Various Georgia Tech researchers have done interesting work in this new field, and the expanding graduate and research programs in the School of Industrial Engineering are resulting in further operations research activity at the institution. We are planning to report some of this work to the readers of this magazine in the near future. In particular, we are looking forward to an article on a project presently underway at the IE School. Dr. Harold Smalley is directing research sponsored by the National Science Foundation on the economics of disposable versus reusable hospital supplies. The work has just begun, and we hope to present some results in the December or February issue.

Tic-tac-terror

• An error of omission occurred in this column in February. We discovered after publication that Dean Ralph Hefner's successful proxy battle with the electronic computer was not over an ordinary game of tic-tac-toe. Rather it was a three-dimensional version and had 16 squares on a side instead of the usual 9. Thus it was possible to score in dozens of ways, with rows through the cube as well as on the side. Mrs. Bess Scott, who served as the Dean's second at the Computer Center, tells us that a game of this complexity is no idle pastime.